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(56) Documents Cited

GB 2084285 A

GB 0746922 A

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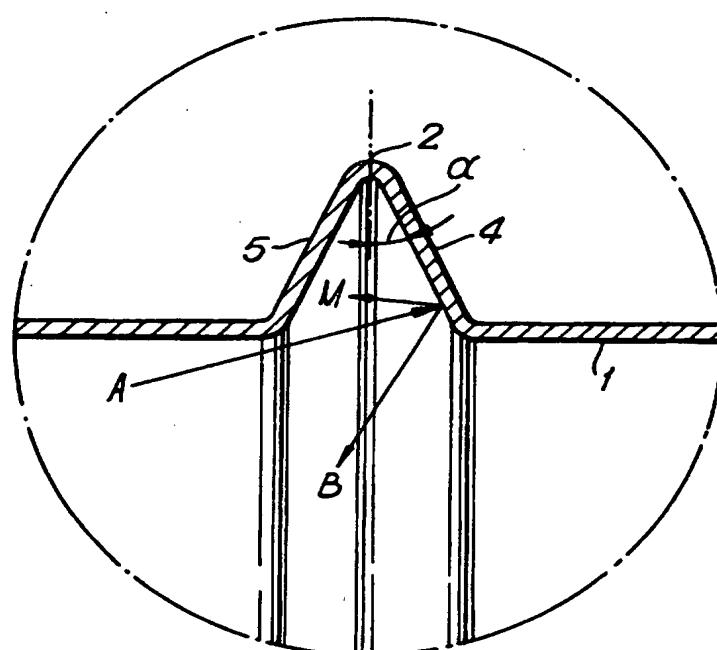
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## (54) Deformable tube with an internal surface of intermittently variable section

(57) The tube, e.g. for conveying gases from a gas burner and acting as a heat exchanger in an oven cooking chamber, is provided integrally with corrugations produced by deforming the tube plastically and radially outwardly, the longitudinal central section of each corrugation of variable section being in the shape of two opposite angles which project outwardly, the pairs of sides 4, 5 of which are formed by segments which are substantially symmetrical with respect to the axis of the tube. Successive corrugations can be adjacent, or are spaced by tube portions of circular section.

Fig.3.



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$\frac{1}{2}$

Fig. 1A.

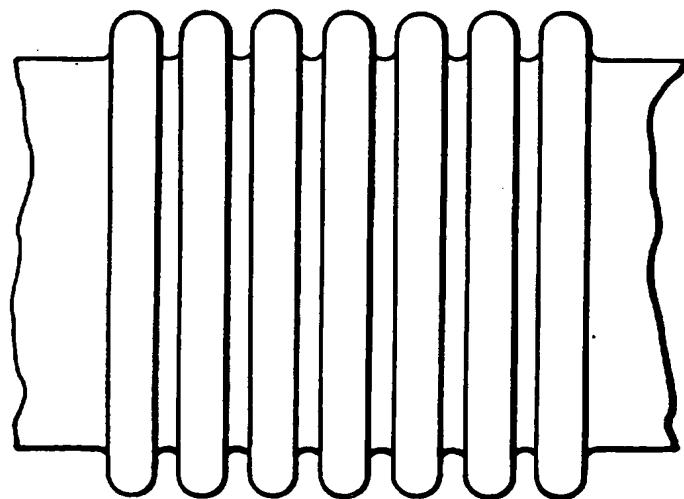
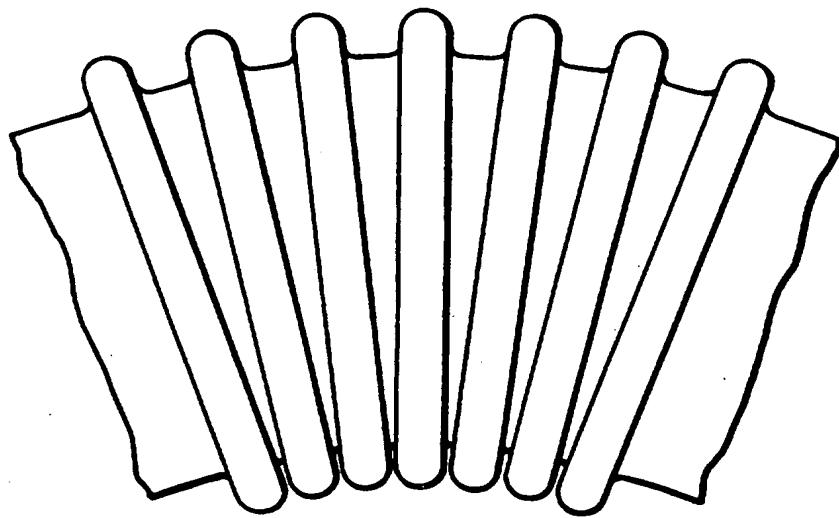


Fig. 1B.



$\frac{2}{2}$

Fig.2.

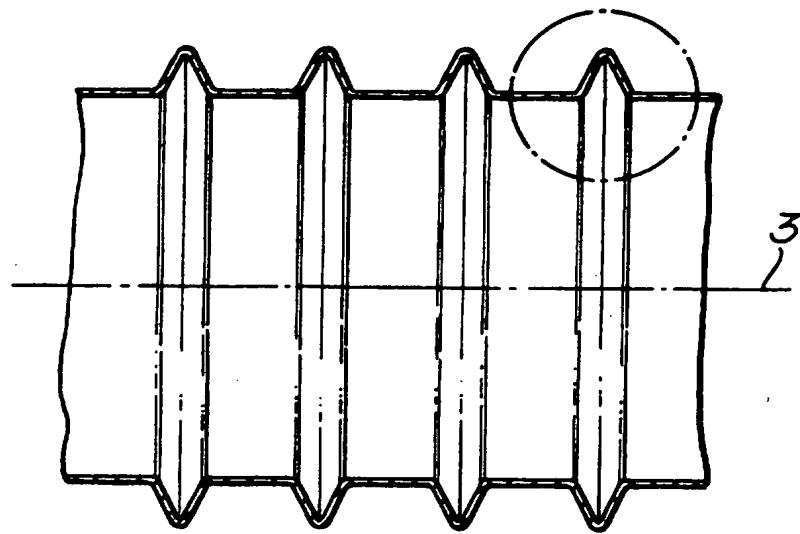
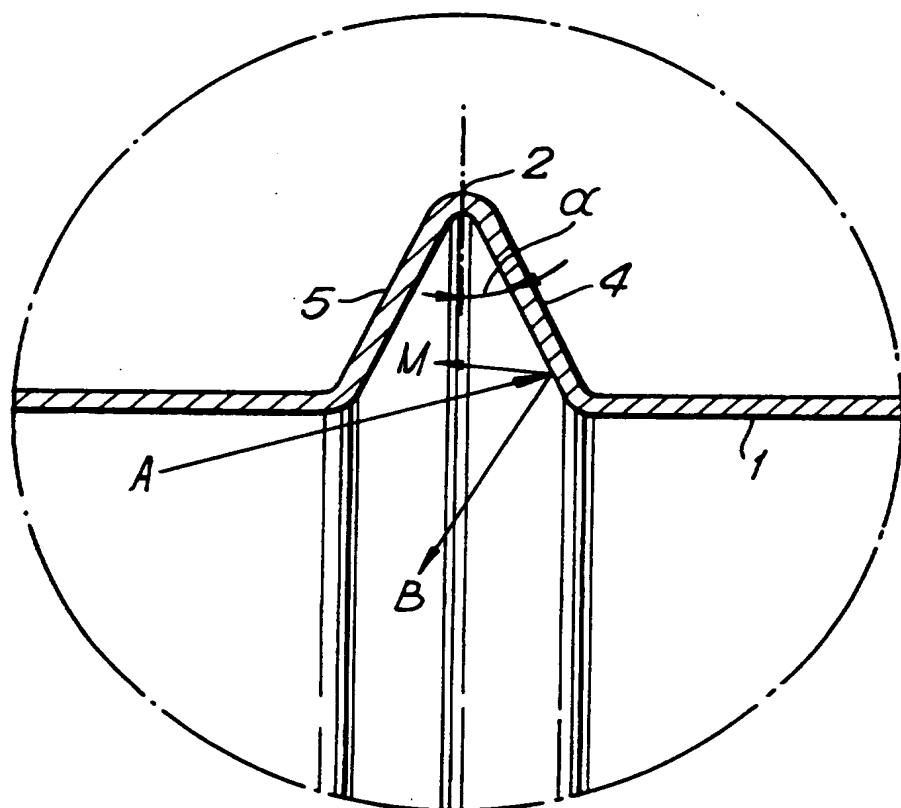


Fig.3.



DEFORMABLE TUBE WITH AN INTERNAL SURFACE  
OF INTERMITTENTLY VARIABLE SECTION

The invention relates to a deformable metal tube  
5 which can be used for conveying fluids, in particular gases,  
and at the same time as a heat exchanger.

In particular the metal tube may be used for  
conveying a flow of burnt gases coming from a gas burner,  
which tube is introduced into a cooking chamber of an oven  
10 for cooking foods, in particular for large numbers.

The hot flow of burnt gases which pass through the  
tube provides for heating of the walls thereof, which in turn  
transfer the heat received to the atmosphere in the cooking  
chamber in which the tube is disposed.

15 Deformable metal tubes are known, whose external  
surface is undulated or corrugated in such a way as to assume  
various shapes; in particular tubes are known which are  
provided with a substantially undulated external profile or  
which are provided with an external profile affording a  
20 succession of outwardly projecting portions, the opposite  
sides of the projecting portions being substantially  
parallel; such a tube is shown in Figures 1A and 1B of the  
accompanying drawings.

It has however been found that if the depth of the  
25 undulation is slight with respect to the diameter of the  
tube, heat exchange thereof is limited; this can be easily  
understood by virtue of the fact that in this case the  
increase in the external surface area which is useful in  
terms of heat exchange is slight with respect to the external  
30 surface area of a cylindrical tube of the same diameter.

Unfortunately, it has been found by experience that  
if on the other hand tubes provided with a pronounced  
undulation are used in order to increase the level of heat  
exchange, then those tubes become troublesomely noisy since  
35 they emit a type of sound similar to a group of whistles.

This phenomenon can also be easily understood; in  
fact the walls of any projection portion disposed in the

direction of the flow of gases, receiving the turbulent pressure of that flow, begin to vibrate and emit corresponding sound waves which are propagated in the interior of the projecting portion and which impinge with the 5 major part of their energy against the frontally disposed opposite wall of the same projecting portion. That also causes excitation of that wall which in turn reflects the received energy, in turn emitting sound waves in the interior of the projection portion; the phenomenon is thus repeated 10 interactively and produces an effect which is well known as a "whistle effect" but amplified by the high number of corrugations or projection portions. That type of tube which offers excellent properties in terms of heat exchange is thus unacceptable because of the troublesome noisiness thereof, in 15 particular in the above-mentioned situation of use.

A type of tube is also universally known, which is generally formed by a substantially cylindrical internal surface and provided on the external surface with a plurality of fins for constituting elements to facilitate heat 20 exchange.

Those fins can be produced in one of the many ways known in the art, for example by mounting fins which have been previously produced separately, or by working the external portion of the tube, or by producing the tube by 25 pressing, or, as disclosed in the Italian patent for a utility model (domestic) No. TO 93A000155 "Deformable metal tube and fin with substantially continuous internal surface", by providing the tube with radial external finning produced integrally with the tube itself, which fins are formed by 30 flattened corrugation of the external surface of the tube and are spaced by substantially cylindrical tube portions.

However all such tubes are substantially the same type of cylindrical tube provided with conventional external fins, and they are distinguished only in terms of the way in 35 which the fins are produced, the fins being obtained by deforming portions of the surface of the tube at suitable intervals.

Therefore those tubes have common functional characteristics: in particular they do not emit a specific noise but obviously they also involve very limited heat exchange due to the fact that, as has been established

5 straightaway, with equality of length and internal diameter of the tube, the area of the internal heat exchange surface is smaller than the corresponding external surface of the same tube portion; that penalises the transfer of heat in particular if the coefficient of convection of heat exchange

10 of the gases which are internal to the tube is less than that outside the tube.

That circumstance causes that finned tube portion to be similar to a cylindrical tube, but the performance of the finned tube can be improved by increasing the density

15 and the diameter of the fins. However, that involves a greater economic burden during production and in use a greater amount of available space which is not always possible to achieve, as in the above-mentioned case of use in a cooking oven.

20 The aim of the present invention is thus to provide deformable metal tubes with optimum properties in respect of heat exchange, which are silent when a continuous and substantial flow of gases passes therethrough, and which can be easily and economically produced with the industrially

25 available technologies and materials.

According to the present invention, there is provided a deformable metal tube provided with a plurality of longitudinal portions of variable cross-sections characterised in that the central longitudinal section of

30 each of said portions of variable section is in the shape of a succession of two opposite angles projecting outwardly, the pairs of sides of which are formed by segments which are substantially symmetrical with respect to the axis of the tube, said succession being disposed along the external

35 surface of the tube.

The invention will be better appreciated from the following description given solely by way of non-limiting

example and with reference to the accompanying drawings in which:

Figures 1a and 1b respectively show a straight exchanger tube and a bent exchanger tube, both in accordance  
5 with the prior art;

Figure 2 is a view in central longitudinal section of an exchanger tube according to the invention; and

Figure 3 shows a portion of a section of an exchanger tube according to the invention.

10 Referring to Figure 2, shown therein is a tube according to the invention. It substantially comprises a preferably cylindrical metal tube 1, on the outside surface of which are disposed a plurality of corrugations 2 which are provided integrally and which are produced by means of an  
15 operation of working the metal surface constituting the external surface of the tube.

The material forming the tube is one of the metals which are generally used for that purpose such as steel, brass, copper, aluminium etc. in order to guarantee both  
20 optimum properties in terms of working the tube and good mechanical strength and workability.

Preferably the corrugations are disposed at regular intervals on the surface of the tube.

25 The shape thereof is substantially pointed and terminates at an angle in the sense that if the tube is sectioned along a plane passing through its central axis, the result obtained is a profile as shown in Figure 2, that is to say a profile which presents the succession of pairs of opposite angles projecting outwardly, the respective pairs of  
30 sides of which are formed by segments which are substantially symmetrical with respect of the axis 3 of the tube.

It will be seen that overall, the flat interior walls of the corrugation substantially form the two equal sides of an isosceles triangle whose third side coincides  
35 with the generatrix of the uncorrugated part of the tube.

The substantial silence of the tube can thus be explained. If a sound wave "A" produced by some turbulence

- in the gases strikes the internal wall 4 which is opposite to the direction of movement of the gas of one of said corrugations 2, in the more general case the greater fraction of the energy of the reflected wave "B" is again diverted 5 towards the interior of the tube and in the opposite direction to the movement of the gas and only a minor fraction "M" is directed towards the opposite internal wall 5 of the respective corrugation, having regard to the inclination " $\alpha$ " of the sides of that corrugation.
- 10 It has been found in fact that, if the angle " $\alpha$ " is increased, the silence of the tube increases in a corresponding fashion since there is an increase in the fraction of energy which is reflected by an internal wall of the corrugations inwardly of the tube with respect to the 15 energy which is reflected against the opposite internal wall, as shown in Figure 3.

It is however also apparent that, upon an increase in the angle " $\alpha$ ", there is a reduction in the capacity for heat exchange, since there is a corresponding reduction in 20 the external heat exchange surface area.

Indeed, in the limit case where the angle " $\alpha$ " reaches its maximum value of  $90^\circ$ , the corrugations are then totally nullified and the tube becomes a simply cylindrical tube which thus has optimum characteristics in terms of 25 silence but the worst heat exchange properties.

In addition a tube of the type described is suitable for being bent and deformed to assume the desired shape without excessively losing its heat exchanger and silence properties.

30 It will be appreciated that the scope of the invention includes a type of tube in which the corrugations occur in succession without interruption, the tube portions of cylindrical section being totally eliminated.

It will be appreciated that the man skilled in the 35 art is perfectly capable of providing a tube as described by using one of the many production procedures known in the state of the art, and also selecting the most appropriate

angle " $\alpha$ " to achieve the desired compromise between the requirements being sought.

## CLAIMS

1. A deformable metal tube provided with a plurality of longitudinal portions of variable cross-sections  
5 characterised in that the central longitudinal section of each of said portions of variable section is in the shape of a succession of two opposite angles projecting outwardly, the pairs of sides of which are formed by segments which are substantially symmetrical with respect to the axis of the  
10 tube, said succession being disposed along the external surface of the tube.
2. A deformable metal tube according to claim 1, and which is provided with a second plurality of longitudinal  
15 portions of circular section.
3. A metal tube according to claim 2, wherein said tube portions of circular section are spaced apart by said tube portions of variable section.  
20
4. A metal tube constructed and arranged to operate substantially as hereinbefore described with reference to and as illustrated in figures 2 and 3 of the accompanying drawings.



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Patent  
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Application No: GB 9602479.9  
Claims searched: 1-4

Examiner: Roger Binding  
Date of search: 17 April 1996

**Patents Act 1977**  
**Search Report under Section 17**

**Databases searched:**

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F2P (PC3, PC9, PF4)

Int Cl (Ed.6): F16L 9/06, 11/15, 11/16

Other:

**Documents considered to be relevant:**

Category	Identity of document and relevant passage	Relevant to claims
X	GB 2084285 A (SIEGWART), note especially Fig 2.	1
X	GB 0746922 A (SHELL), see especially page 2, lines 101-105.	1
X	GB 0597363 A (METALLSCHLAUCHFABRIK), see especially Fig 4 and page 2, lines 99-101.	1-3
X	WO 85/01093 A1 (GEBELIUS), Figs 1-4; note especially page 1, line 7 and page 7, line 34.	1-3
X	US 4852616 A (HOLCOMB), see fig 3 and column 5, lines 21-28.	1-3
X	US 3847186 A (BAUER), see Figs 4 & 7 and column 3, lines 9-19.	1-3
X	US 3847184 A (GOD)	1-3

- X Document indicating lack of novelty or inventive step  
Y Document indicating lack of inventive step if combined with one or more other documents of same category.  
& Member of the same patent family

- A Document indicating technological background and/or state of the art.  
P Document published on or after the declared priority date but before the filing date of this invention.  
E Patent document published on or after, but with priority date earlier than, the filing date of this application.